Final Project Report

Capitola Village Drainage Improvement Project

City of Capitola

Agreement # 06-106-550-1

Proposition 40, Clean Beaches Initiative Grant

Prepared for State Water Resources Control Board and
Central Coast RWQCB

September 2010

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I Problem Statement & Relevant Issues

Introduction

The City of Capitola was awarded a grant of $600,000 from the Proposition 40, Clean Beaches Initiative Program in November 2006 for the Capitola Village Drainage Improvement Project. The grant agreement (#06-106-550-0) was finalized on April 6, 2007 and amended on August 14, 2008 (#06-106-550-1). This is the final report on the project, which spanned April 2006 – December 2009, with post-construction monitoring continuing through July 2010. All activities in the grant-funded project, including final invoice payment were completed in September 2010. The grant contribution was $600,000, which was the total project cost.

Water Quality in Soquel Creek Lagoon and Capitola Beach

Soquel Creek flows from the Santa Cruz Mountains to Capitola, where it forms Soquel Creek Lagoon as it discharges to Monterey Bay. During the summer months, a berm is placed across the mouth of Soquel Creek to create the Lagoon. The Lagoon is maintained from Memorial Day to the onset of winter storms in any given year with a pipe that outlets creek flow to discharge onto the beach.

Located at the edge of Capitola Village, a town of about 10,000 people, Capitola Beach is one of the most popular beaches in Santa Cruz County and is a cornerstone of the local economy. The beach is a focal point for special events in the community. The waterfront includes a row of shops and restaurants—known as the Esplanade—a wharf with restaurants and businesses, and historic residential areas.

Capitola Beach, which is within the Monterey Bay National Marine Sanctuary, is also home to many protected species including sea otters, marine mammals and sea birds. Soquel Creek and Lagoon also provide habitat for steelhead trout, and both are identified as having potential for reintroduction of coho salmon.

Three stormwater drains discharge directly onto the beach or lagoon. At least five other stormwater drains in Capitola discharge to Soquel Creek upstream of the Lagoon. Periodically, the waters at Capitola Beach are posted as being unsafe for body contact. From 2001-2004, and again in 2009, Capitola Beach was listed on Heal the Bay's list of the 20 worst beaches in California. It has consistently had some of the highest fecal coliform counts in Santa Cruz County. As with most coastal lagoons in Santa Cruz County, Soquel Lagoon at Capitola Beach is permanently posted as unsafe for human contact. The waters off the beach are monitored by the County of Santa Cruz and posted when bacteria levels are high.

Bacterial contamination on Capitola Beach and Soquel Lagoon is attributed to many factors, including high numbers of birds roosting around the Lagoon and beach, urban runoff in the upper and lower watershed, leaky sewer lines and manholes. Management plans recommended several water quality improvement projects. Prioritization, inter-agency coordination and conceptual planning of these projects were accomplished with a Clean Beaches Initiative grant in 2004. As a

result, the Village Drainage Improvement Plan was produced, which identified eleven priority projects. The projects in Agreement # 06-106-550-1 were priorities identified in this Plan.

Treatment Wetland

In 2008 the City of Capitola Public Works Department focused on constructing a treatment wetland on ¼ acre of city-owned property adjacent to Soquel Lagoon to assist with water quality improvement in the Lagoon. The design was completed in early Spring 2008 and revised in April 2008 in order to reduce estimated costs. The construction contract was awarded August 14, 2008.

Also in August 2008, the State Water Board and City of Capitola made a change to the grant agreement (deviation request) in order to facilitate installation of two stormwater diversions for urban runoff. Previously, the locations and design of the diversions were undetermined. Now the two diversions are designed to discharge into the wetland, which will treat runoff prior to discharge to Soquel Lagoon. The wetland system is designed to be able to handle flows from small rainstorms and the initial portion of "First Flush" rain events, in addition to dry weather flows.

The City modified plans from another stormwater diversion for use in the new locations, and used a contract change order to modify the wetland construction contract to accomplish this work. The goal of these collective efforts has been to not only prevent polluted runoff from entering Soquel Lagoon and Capitola Beach, but to treat pollution that cannot be intercepted, such as the bird and wildlife waste.

II Project Goals and Objectives

Purpose

The project consisted of constructing a biofiltration wetland on ¼ acre of city-owned property adjacent to Soquel Lagoon. Creek water is pumped up to the wetland for treatment; in addition, two dry weather diversions were installed on storm drain outfalls that discharge to the wetland, treating runoff prior to discharge to Soquel Lagoon.

The wetland system was designed to treat flows from the creek and also small rainstorms and the initial portion of "First Flush" rain events, in addition to dry weather flows. Pre and post-project monitoring was included in the overall scope of work. The wetland is intended to assist with water quality improvement in the Soquel Creek Lagoon during the summer months when a berm is placed across the mouth of Soquel Creek to create the Lagoon. The treatment wetland is a component of the City's overall strategy to address the recurring water quality issues in the Soquel Creek Lagoon.

Goal and Objectives

The goal of this effort was to eliminate all beach postings (permanent and intermittent) on Capitola Beach and Soquel Creek Lagoon.

The water quality objective was to prevent polluted runoff from entering Soquel Lagoon and Capitola Beach and reduce the discharge of pollutants such as:

- Tastes and Odors
- Floating Material
- Suspended Material
- Oil and Grease
- Biostimulatory Substances
- Pesticides
- Settleable Material
- Bacteria and Pathogens

III Project Description

Background

In the two years prior to receiving the Clean Beaches Initiative grant in 2006, the City of Capitola evaluated the feasibility of constructing a biofiltration wetland to improve water quality in Soquel Creek Lagoon. The City worked with Harris & Associates, a civil engineering firm, and Sycamore Associates LLC, a biological resources consulting firm, on an initial analysis of the potential for a constructed wetland to be successful in improving water quality in the Lagoon.

Water quality experts Weston Solutions, Inc. (Weston) prepared a data gap analysis of the existing water quality data and examined the potential efficacy of a wetland in treating water from the Lagoon.

Weston determined the development of a subsurface flow constructed wetland would likely reduce the bacterial concentrations of the treated water. However, the report noted that bacteria from other sources may continue to enter Soquel Creek Lagoon, thereby, reducing the overall net effect of the wetland treatment. An understanding of the overall load from each of the sources and physical processes would be necessary to determine the precise net benefit the wetland would have to water quality in Soquel Creek Lagoon.

Weston reported that removal of bacterial indicators in water treated through constructed subsurface flow wetlands had been documented in several studies. In all cases, bacterial densities had been reduced by at least 1 order of magnitude, with up to 3 orders of magnitude reduction observed for fecal coliform in one particular study.

Design

With the Clean Beaches Initiative grant, The City of Capitola contracted with Harris and Associates Engineers to design the project. All necessary permits were approved and received by September 2007. The permit restrictions created a few parameters for certain aspects of construction. The construction schedule included the following:

- Bulkhead Retrofit: Winter 2007-2008
- Bio-Swale: February-March 2008
- Intake System: May 2008

Harris and Associates submitted a design proposal to City Council in August 2007, which the company had to revise due to higher-than-expected construction costs. The increased cost was primarily attributed to the high cost of reinforced concrete for the bulkhead adjacent to Soquel Creek. The City directed Harris and Associates to find a lower-cost alternative. The selected alternative retained the same wetland design, but placed it 4 feet back from the riverbank. The reinforced concrete was replaced with a liner and rock infill. The new location required a retaining wall for the adjacent slope. No changes to permits were required. The change in plans delayed the project by three months, but resulted in significant cost savings—about half the original estimate.

The wetland design is a commercially available modular system designed by Aquascape Designs, and is referred to as a "Centipede and Snorkel Constructed Wetland." Diagrams of the design are included in Appendix C. The filtering system works by pumping water from a water body—in this case the Soquel Creek Lagoon—and circulating it through a series of perforated pipes overlain by a gravel bed and planted with wetland vegetation. An overflow allows circulated water to return to the creek. Two dry weather diversions on two stormwater outfalls near the wetland were installed. These direct dry weather flows and the first part of the First Flush to the wetland.

A sub-surface constructed wetland system was used because this type of wetland system eliminates surface water, thus reducing the potential for mosquito breeding and algal growth. Eliminating the possibility for algal growth helps to reduce secondary production of biological oxygen demand (BOD) within the system. Sub-surface wetland systems properly designed, operated, and maintained can also effectively reduce suspended solids, nitrogen, metals, and other pollutants in wastewater.

Construction of Treatment Wetland

The project proposal was approved by City Council April 24, 2008, and the bids were opened July 9, 2008. The project was awarded to low bidder Earthworks Paving Contractors, a local firm. The original bid was in the amount of $351,100, which exceeded the funding level. Through value engineering and negotiations with the contractor, the bid was reduced to $250,000.

The Notice to Proceed was issued on September 8, 2008 to Earthworks Contractors and construction commenced on this date. The City negotiated a contract change order on October 17, 2008 with Earthworks Contractors to include a dry weather pump station for the two dry weather diversions. By January 2009, 95% of construction was complete, and the pumps were operating at a level necessary to keep the new plants alive.

By March 2009, 100% of the wetland had been constructed, was fully operational, and was discharging treated water. Both dry weather diversions were installed and fully operational at that time as well. All construction work was inspected frequently for quality and conformance to plans by the City's Project Manager as well as the City's project inspectors. The Notice of Completion for both construction of the wetland and installation of the two dry weather diversions were issued March 12, 2009.

Starting in June 2009 and continuing to the present, the City began working with George McMenimum, a consultant botanist, to evaluate the effectiveness of the plants in the wetland and make recommendations for any changes. The City worked with McMenimum to substitute some faster-growing, salt tolerant plants in the wetland due to the fact that the root mass of the plants needed to be of sufficient size to provide treatment properties.

McMenimum submitted a plant report in August 2010, which is included in Appendix B. The report concluded that the wetland will likely provide a small patch of habitat, as the Juncus and several other plant species are attractive food sources for waterfowl and may also provide a limited nesting location. Additionally, some of thee plant species in the wetland are quite

attractive and could be used for educational purposes. It was recommended in the plant report that collection of data related to nutrient/salinity uptake and plant growth and development continue for at least two more years.

Monitoring

Water quality monitoring was a requirement associated with the grant funding. The City contracted with Coastal Watershed Council (CWC), a local non-profit, to implement construction monitoring for the wetland. The contract was approved on July 24, 2007.

CWC coordinated with the County of Santa Cruz Environmental Health Services and the Regional Coordinated Monitoring Program to create a Monitoring Plan. CWC (Tamara Doan, Project Director) submitted a pre-construction Monitoring Plan and Quality Assurance Project Plan (QAPP) in July 15, 2008, which was revised October 10, 2008.

The Monitoring Plan recommended:

1) Establishing baseline ambient water quality data before constructing the wetland treatment system, and then monitoring after the installation, so the City would be able to compare pre- and post-construction conditions in Soquel Creek, and
2) Monitoring at the wetland inlet and outlet, so the City would be able to evaluate the water quality performance of the wetland treatment system directly.

The goal of the water quality-monitoring program outlined in the Monitoring Plan was to assess the effectiveness of a constructed wetland treatment system project in improving water quality conditions in Soquel Creek and the Soquel Creek Lagoon. The objectives of the monitoring program were:

1. to measure the ambient water quality conditions at several points along Soquel Creek as it passes through the City of Capitola, including Soquel Lagoon, both before and after the construction of a wetland treatment system, and
2. to evaluate the water quality treatment performance of the constructed wetland by monitoring the intake (Soquel Creek water) and the point of discharge from the wetland treatment system.

Pre-Construction Monitoring

A Monitoring Progress Report was submitted by CWC (Nik Strong-Cvetich Associate Director) to the City on July 20, 2009. The results of pre-construction monitoring provided a water quality baseline, which was used to compare the results of the post-construction water quality monitoring.

CWC measured ambient water quality conditions at five stations along Soquel Creek as it passes through the City of Capitola and discharges to the ocean prior to construction to document baseline conditions in Soquel Creek and the Soquel Creek Lagoon. This was done during a 30-day period in between September 30, 2008 and October 29, 2008, between the hours of 11 a.m. and 3 p.m. to characterize conditions during periods of highest public recreational use. The treatment system area comprises about ½ acre along the western bank of Soquel Creek, immediately upstream and adjacent to Stockton Ave Bridge.

Post-Construction Monitoring
Post-construction monitoring occurred from September 11, 2009 to August 12, 2010. Post-construction monitoring was conducted in the same vicinity as pre-construction monitoring, except for one pre-construction site replaced by the wetland itself.

Both pre- and post-construction motoring results were compared to the Water Quality Objectives (WQOs) found in the Central Coast Region Basin Plan, and Attention Levels established by the Central Coast Regional Water Quality Control Board. Monitoring results are discussed in Section V of this report. The Monitoring Report was submitted to the City by CWC in August 2010. It is presented in its entirety, including data and the Quality Assurance Project Plan, in Appendix E.

PHOTOS
Photo documentation did occur and all SWRCB reporting requirements were met including 11 progress reports, eight grant program invoices, annual reports in 2007 and 2008, and progress and final Monitoring Reports.

Photo 1 - Site of Capitola's biofiltration wetland prior to construction.

Photo 2: Capitola Beach

Photo 3: Dry weather stormwater diversion on east side of bridge

Photo 4: Dry Weather Diversion on west side of creek. This is a gravity diversion where all low flows divert to the wetland.

Photo 5: Project area showing new bulkhead and wetland.

IV Monitoring Results

Pre-Construction Monitoring

In pursuit of the goals set out in the Monitoring Plan, CWC monitored five sites in the vicinity of the wetland treatment system prior to construction, to document baseline conditions in Soquel Creek and the Soquel Creek Lagoon. This was done during a 30-day period between September 30, 2008 and October 29, 2008 between the hours of 11 a.m. and 3 p.m. to characterize conditions during periods of highest public recreational use. A complete list of pre-construction monitoring dates is listed in the Monitoring Report in Appendix E.

The sites monitored are as follows (see Figure 1):

1.	Discharge of Soquel Creek at Pacific Ocean	Station ID: 304-SOQUE-23
2.	Soquel Creek at Lagoon Outlet	Station ID: 304-SOQUE-22
3.	Soquel Creek at Wetland Intake (Stockton Bridge)	Station ID: 304-SOQUE-24
4.	Wetland Outlet*	Station ID: 304-CAPWE-01
	*(Soquel Cr at same location before construction)	Station ID: 304-SOQUE-27
5.	Soquel Creek at Trestle Bridge	Station ID: 304-SOQUE-25

Figure 1. Water-quality monitoring locations.

The treatment system area comprised about ¼ acre along the western bank of Soquel Creek, immediately upstream and adjacent to Stockton Ave Bridge. Each monitoring event included sampling for the following water quality parameters: pH, dissolved oxygen, air & water temperature, electrical conductivity, salinity, TDS, TSS, ammonia, nitrate, orthophosphate, turbidity, *E. coli* bacteria, total coliform bacteria, hardness, total organic carbon, and biochemical oxygen demand. Samples were delivered to Santa Cruz County Department of Environmental Health Services (SCCoDEHS) and UC Santa Cruz Shennen Laboratory.

High levels of *E. coli* bacteria were routinely observed in the analytical results of pre-construction monitoring. Low levels of dissolved oxygen and elevated levels of ammonia were observed during one monitoring event.

The results of the five pre-construction monitoring events are shown in Table 1. These results provide a water quality baseline, which were used to compare the results of the post-construction water quality monitoring. The results are considered preliminary pending additional quality control review.

Results were compared to Water Quality Objectives (WQOs) found in the Central Coast Region Basin Plan, and Attention Levels established by the Central Coast Regional Water Quality Control Board. Inspecting the results for each of the parameters, it was found that at least one exceedance occurred for *E. coli* bacteria, dissolved oxygen, ammonia, and pH.

Table 1. Water quality monitoring, pre-construction (preliminary results)

Soquel Creek Monitoring Data																		
StationID	Sample Date	Sample Collection Time	Air Temp °C	EC mS	DO mg/L	pH	SALIN ppt	TDS g/L	TURB NTU	Water Temp °C	NO3 ppm	PO4 ppm	ECOLI MPN/ 100mL	Tcoli MPN/ 100mL	NH3 ppm	Hardness mg $CaCo_3$/L	TOC mg/L	BOD
WQO / ATTN level				>2000	<7.0	7.0-8.5>				>22	>2.25	>0.12	>235	>10000	>0.025			
SOQUE-22	9/30/2008	13:55	21	0.74	6.25	7.86	0.41	0.54		19.2	<.05	<.01	241	1935	0.05	425	7.46	7.46
SOQUE-23		14:10	21	no data	8.3	7.6	no data	no data		18.5	<.05	0.1	512	5794	0.08	835	16.14	9.60
SOQUE-24		13:40	19.5	0.75	6.48	7.9	0.41	0.55		19.3	<.05	<.01	72	3076	0.05	300	2.57	10.11
SOQUE-25		13:00		0.74	7.61	7.93	0.41	0.54		19.3	<.05	<.01	41	3076	0.04	260	10.08	8.32
SOQUE-27		13:30	20.5	0.75	8.32	7.96	0.41	0.55		19.3	<.05	<.01	85	2247	0.04	no data	no data	8.99
SOQUE-22	10/21/08	12:25	17	0.94	10.2	8.23	0.46	0.61		15.8	<.05	<.01	529	3448	<.03	300	10.11	7.08
SOQUE-23		12:50	No Data due to high tide at the flume															****
SOQUE-24		12:05	15	0.94	9.38	8.15	0.47	0.61		15.8	<.05	<.01	369	2236	<.03	275	12.69	5.50
SOQUE-25		11:05	14	0.87	9.44	8.21	0.45	0.57		15.8	<.05	<.01	110	1314	<.03	275	3.95	8.03
SOQUE-27		11:30	15	0.94	10.1	8.11	0.46	0.61		15.8	<.05	<.01	223	1607	<.03	260	12.28	7.10
SOQUE-22	10/23/08	13:00		0.93	10.8	8.25	0.46	0.6		15.7	<.05	<.01	934	2142	<.03	255	5.69	5.39
SOQUE-23		13:20		0.98	10.6	8.09	0.49	0.63		16	<.05	<.01	565	2481	<.03	350	9.53	5.15
SOQUE-24		12:45		0.93	10	7.08	0.46	0.61		15.9	<.05	<.01	1119	3076	<.03	245	13.24	5.94
SOQUE-25		12:00		0.76	9.29		0.46	0.6		15.6	<.05	<.01	135	1597	<.03	255	0.00	6.08
SOQUE-27		12:30	24	0.77	9.38	6.85	0.46	0.61		15.5	<.05	<.01	432	3654	<.03	260	6.86	6.30
SOQUE-22	10/28/08	14:30		0.91	9.35	7.52	0.45	0.59		16.1	<.05	<.01	703	3448	<.03	no data	no data	no data
SOQUE-23		14:50		1.99	9.15	7.52	0.98	1.22		16	<.05	<.01	794	3664	<.03	no data	no data	no data
SOQUE-24		14:20		0.91	8.57	7.67	0.45	0.59		16.1	<.05	<.01	364	3664	<.03	no data	no data	no data
SOQUE-25		13:35	27	0.9	9.07	8.08	0.44	0.58		16	<.05	<.01	185	1722	<.03	no data	no data	no data
SOQUE-27		14:05		0.91	8.52	7.9	0.45	0.59		16.1	<.05	<.01	292	2909	<.03	no data	no data	no data
SOQUE-22	10/29/08	14:35	21.5	0.9	9.42	8.13	0.45	0.59	3.14	15.9	<.05	<.01	697	6867	<.03	no data	no data	4.41
SOQUE-23		15:00	19	1.2	9.39	8.07	0.56	0.79	16.6	15.9	<.05	0.154	727	6867	<.03	no data	no data	4.46
SOQUE-24		13:56	17	0.9	8.44	8.01	0.45	0.59	3.18	15.8	<.05	<.01	683	2755	<.03	no data	no data	4.17
SOQUE-25		12:55	16	0.9	8.89	8	0.44	0.58	3.47	16.2	<.05	<.01	292	2909	<.03	no data	no data	5.03
SOQUE-27		13:30	16		8.95	7.93	0.45	0.59	2.67	15.8	<.05	<.01	422	5475	<.03	no data	no data	3.59
# of exceedences				0	2	1		0		0	0	1	17	0	5			
% of samples exceeding				0%	8%	4%				0%	0%	4%	71%	0%	21%			
Max				1.99	10.8	8.25	0.98	1.22	16.6	19.3	0	0.15	1119	6867	0.08	835	16.14	10.11
Min				0.74	6.25	6.85	0.41	0.54	2.67	15.5	0	0.1	41	1314	0.04	245	0	3.59
Ave				0.93	9	7.8717	0.48	0.62	5.81	16.6	<.05	0.13	438.6	3248	0.052	330.4	8.509	6.458
Median				0.9	9.22	7.96	0.45	0.59	3.18	15.9	<.06	0.13	395.5	2993	0.05	275	9.531	6.077

- Indicates exceedance of WQO or Attention Level (preliminary assessment)

In Summary: Pre-construction monitoring showed high *E. coli* bacteria counts observed across events and sites. This illustrates one of the main reasons for the construction of the wetland treatment system. One of the project goals is to reduce the bacteria counts in the Lagoon and the frequency of WQO exceedences, yielding human health and environmental benefits in the lagoon and beach area. The presence of *E. coli* bacteria may be attributed to anthropogenic and

avian sources. The pre-construction monitoring results provided a useful baseline for comparison to post-construction water quality.

Post-Construction Monitoring
Post-construction monitoring was delayed due to state budget issues, which caused this grant to be "frozen" from December 2008 through October 2009. Monitoring began when the state confirmed that grant reimbursement would continue. Post-construction monitoring occurred from September 11, 2009 to August 12, 2010. A complete list of pre-construction monitoring dates is listed in the Monitoring Report in Appendix E. Post-construction monitoring was conducted in the same vicinity as pre-construction monitoring, except for one pre-construction site replaced by the wetland itself. Samples were delivered to Santa Cruz County Department of Environmental Health Services (SCCoDEHS) and Caltest Lab.

CWC took four approaches to assess the effectiveness of the wetland on improving water quality: comparing wetland inlet vs. wetland outlet sites, comparing upstream vs. downstream sites, comparing pre-construction vs. post-construction results, and comparing results to water quality objectives.

Spatial analysis: Wetland inlet vs. outlet
Averages were calculated using the results for all parameters of interest measured on post-construction monitoring dates. For some parameters of interest, this comparison shows that the wetland improved the quality of the water taken from the creek. For example, for both *E. coli* and total Coliform, which are key bacteria indicators, lab results indicate that the wetland was effective in removing a noticeable level of these pathogens. Looking at a similar comparison of nutrient levels, however, reveals a less optimal result: levels of ammonia, nitrate and orthophosphate all increased upon passage through the wetland.

Spatial analysis: Soquel Creek upstream vs. downstream
An expansion of this spatial analysis compared results for Soquel Creek sites upstream and downstream from the treatment wetland. The Trestle Bridge site (SOQUE-25) is a couple hundred feet upstream from the wetland, and the Soquel Lagoon Outlet Site (SOQUE-22) is several hundred feet downstream. This comparison showed nutrient levels were lower on average at the downstream Soquel Creek location. Total Coliform levels also were slightly lower downstream, in the lagoon, than upstream, near the trestle bridge, but the opposite was true for *E. coli.* The elevated downstream *E. coli* levels may be partially explained by the presence of seagulls and ducks regularly observed in the lagoon. Looking at other parameters, slight improvements in water quality were seen for turbidity and BOD at the downstream site, but temperature, EC and TSS were higher in the downstream samples.

Temporal or "before and after" comparison
For these comparisons, three sites at or downstream of the constructed wetland were selected: SOQUE-24 (Wetland Intake), SOQUE-22 (Lagoon Outlet) and SOQUE-23 (Soquel Creek discharge to ocean). The pre-construction vs. post-construction results were mixed for nutrients and bacteria. Ammonia levels decreased at all three sites when comparing pre- to post-construction averages. Nitrates increased at two sites in the post-construction data, and were unchanged at one site. Phosphate levels decreased at two sites but increased at one. The results

for indicators of bacteria were also mixed, with average *E. coli* levels decreasing at all sites, but average total Coliform levels increasing at all sites in the pre- vs. post-construction comparison.

Regulatory comparison
The objectives used for this analysis were the Central Coast Regional Water Quality Control Board's water quality "attention levels" and the Draft Guidance for Fresh Water Beaches drawn up by the California Department of Public Health (CDPH)[1].

To assess the effectiveness of the constructed wetland in improving water quality, monitoring results were compared to applicable water quality objectives. The objectives used for this analysis were the Central Coast Regional Water Quality Control Board's water quality "attention levels" and the Draft Guidance for Fresh Water Beaches drawn up by the California Department of Public Health (CDPH)[2]. For *E. coli*, the CDPH guidelines are equivalent for freshwater and saltwater beaches, and establish a limit of 126 MPN/100 mL for the log mean of five samples collected during a 30-day period.

Table 10 lists these log mean results, and shows that *E. coli* levels at the sites closest to the beach (SOQUE-22 and SOQUE-23) exceeded the limit for all sets of pre- and post-construction water quality monitoring. Table 10 also shows that *E. coli* decreased when comparing levels in water entering (SOQUE-24) and exiting (CAPWE-01) the wetland. As the volume of water being treated by the wetland is very small relative to the overall flow of Soquel Creek, this reduction in *E. coli* levels was not detected when comparing upstream and downstream sites. But, because *E. coli* levels dropped when comparing bacteria counts in water entering and exiting the wetland, we can conclude that for *E. coli*, a key water quality parameter, the wetland was improving the quality of the water.

Table 10 also demonstrates some other encouraging results. First, for samples taken near the wetland intake (SOQUE-24), all post-construction *E. coli* levels were lower than the pre-construction level. Furthermore, there is a clearly demonstrated downward trend in these results. Secondly, for SOQUE-23, a key site since this discharge to the ocean most immediately affects swimmers at Capitola Beach, three out of four post-construction *E. coli* levels were lower than the pre-construction level. Lastly, of the four sets of post-construction monitoring results at CAPWE-01 (the wetland outlet), only one exceeded the water quality objective, and all were among the lowest of *E. coli* results for all sites.

Table 10: 30-day log mean values for E. coli monitoring results. All values are listed as MPN/100 mL. Dark grey cells indicate an exceedance compared to CDPH Draft Guidelines. Table shows one set of pre-construction results and four sets of post construction results.

[1] http://www.cdph.ca.gov/HealthInfo/environhealth/water/Documents/Beaches/DraftGuidanceforFreshWaterBeaches.pdf, Last Update: May 8, 2006

[2] http://www.cdph.ca.gov/HealthInfo/environhealth/water/Documents/Beaches/DraftGuidanceforFreshWaterBeaches.pdf, Last Update: May 8, 2006

Site ID	Site Description	Pre - Const	Post Construction			
		Set 1	Set 1	Set 2	Set 3	Set 4
		Oct 2008	Sept 2009	June 2010	July 2010	Aug 2010
SOQUE-25	Trestle Bridge	127	275	293	132	131
CAPWE-01	Wetland Outlet	N/A	86	201	36	87
SOQUE-24	Wetland Intake	*376	274	269	84	77
SOQUE-22	Lagoon Outlet	567	961	399	235	393
SOQUE-23	Discharge to ocean	573	*696	397	282	412

*These log mean values are based on only 4 monitoring results rather than 5.

In Summary: Using comparisons of measured levels of key water quality parameters to regulatory objectives, as well as upstream and downstream comparisons, and before and after comparisons, the wetland's effectiveness in improving water quality is limited. The up/downstream and before/after comparisons showed that for some parameters, the quality of the water improved, while for others, it deteriorated. Most promising, the constructed wetland does prove to be effective in reducing *E. coli* levels in water as it passes through the wetland.

This is based on a reduction in measured *E. coli* bacteria counts for water entering the wetland, compared to *E. coli* bacteria counts in water exiting the wetland. While this reduction was not detectable in sites further downstream of the wetland, this is likely due to the fact that the volume of water being treated by the wetland is a very small relative to the overall flow of Soquel Creek. Another confounding factor involved with bacteria counts at downstream sites is the presence of waterfowl in and near the lagoon and beach. Notwithstanding these factors, the monitoring results demonstrate a reduction in bacteria for water passing through the wetland.

While the wetland's effect on the overall health of the creek is not remarkable, its continued operation would seem to be beneficial to the creek, lagoon and nearby beach. In partnership with the infrastructure projects such as storm drain and outfall improvements, and ongoing public education campaigns by the City of Capitola and its partners, this project is one of many positive steps the City is taking to protect the creek and improve the surrounding area for fish, wildlife, and City residents and visitors.

Data relating to all results can be found in the final Monitoring Report, which is presented in its entirety, including data and Quality Assurance Project Plan, in Appendix E.

V Discussion

Wetland Function for Water Quality Improvement: Based on pre-and post-construction monitoring results, the wetland's effectiveness in improving water quality appears to be limited, as some water quality parameters showed improvement while others deteriorated, and the results from one type of analysis are often countered by another type of analysis. The constructed wetland has proven effective in reducing *E. coli* levels in water as it passes through the wetland. The only exception is the result from the upstream vs. downstream analysis, which is a comparison that is apparently complicated by the presence of waterfowl in and near the lagoon. Using this key parameter, which is used by several regional and state agencies for public health and other regulatory purposes, the wetland has had a positive effect on water quality in Soquel Creek.

Wetland Plant Growth: In general, plants in the wetland are surviving, growing and producing flowers. Enough species are established to provide some wetland function. However, continued root development and increases in plant density and diversity, are needed to achieve a more effective uptake of nutrients. Only *Scirpus californicus* and *Typha augustifolia* were growing in sufficient numbers as of August 2010. Correlation of data related to actual nutrient uptake and salinity is needed in conjunction with continued plant growth data to draw final conclusions on the effectiveness of the wetland at improving water quality. Monitoring of wetland plant growth showed that additional species and numbers of plants are needed to achieve optimum function of the wetland. The City has contracted with George McMenimum, consultant botanist, to do additional plantings and monitor growth.

Dry Weather Diversions on Two Stormwater Outfalls: The project reduced discharge of dry weather urban runoff into the receiving waters of Monterey Bay, Soquel Creek Lagoon and Capitola Beach.

Water Quality Monitoring: The monitoring program was implemented by Coastal Watershed Council (CWC) utilizing a contract with the City; and was coordinated with other water quality monitoring efforts in the vicinity.

The monitoring program described in the Monitoring Plan was designed to demonstrate the improvement of water quality in Soquel Creek as a result of the construction of a biofiltration wetland. This was done in two ways:

1) by providing water quality data for key constituents from selected locations before and after construction and operation of the treatment wetland, and

2) by providing water quality data for key constituents upstream and downstream of the wetland, and at the inlet and outlet of the wetland, once the wetland is operational.

The final Monitoring Report is presented in its entirety, including data and Quality Assurance Project Plan, in Appendix E.

VI Conclusions

The Capitola Village Drainage Improvement Project was completed on time and within budget and all project goals were met. The project achieved the following outcomes:

- construct a treatment wetland on ¼ acre of City-owned property;
- install dry weather diversions on two storm drain outlets between Stockton Avenue and the railroad trestle above Lagoon;
- monitor effectiveness of treatment wetlands for one year.
- administer, coordinate and report on the project

The goal of this effort was to eliminate all beach postings (permanent and intermittent) on Capitola Beach and Soquel Creek Lagoon. While the project has not yet met the goal to eliminate *all* beach postings (permanent and intermittent) on Capitola Beach and Soquel Creek Lagoon, the constructed wetland has proven effective in reducing *E. coli* levels in water as it passes through the wetland.

The water quality objective was to prevent polluted runoff from entering Soquel Lagoon and Capitola Beach and reduce the discharge of pollutants. Using reduced *E. coli* levels as a key parameter, which is used by several regional and state agencies for public health and other regulatory purposes, we can conclude that the wetland has had a positive effect on water quality in Soquel Creek. Furthermore, as the City continues to improve the plant growth in the wetland, increases in the treatment level of effluent can be expected. Finally, based the success from this wetland in treating the *E. coli* levels, the City will search for other upstream sites for construction of new wetland systems.

While the wetland's effect on the overall health of the creek is not remarkable, its continued operation would seem to be beneficial to the creek, lagoon and nearby beach. In partnership with the infrastructure projects such as storm drain and outfall improvements, and ongoing public education campaigns by the City of Capitola and its partners, this project is one of many positive steps the City is taking to protect the creek and improve the surrounding area for fish, wildlife, and City residents and visitors.

Capitola collaborates in ongoing regional water quality monitoring efforts including: First Flush, Urban Watch, Snapshot Day, AB 411 Beach Water Quality monitoring and the water quality monitoring performed by Santa Cruz County Environmental Health Services along Soquel Creek. Through these efforts and others, the City will continue to gather information about the effectiveness of the installed measures.

The City of Capitola gratefully acknowledges the contributions of the State Water Resources Control Board and the financial contribution of the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002 (Proposition 40) approved by the voters of California. Funding for this Project has been provided in full or in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

APPENDIX A
Summary of Deliverables

Item	DESCRIPTION	Due Date	% Of Work Complete	Date Submitted
1.1 EXHIBIT A	Quality Assurance Project Plan	May 2007	100%	7/15/08, revised 10/10/08
1.2	Monitoring Plan	May 2007	100%	7/15/08, revised 10/10/08
2.1	Construct Wetland	—	—	—
2.1.1	Construction Plans	Oct 2007	100%	4/15/08
2.1.3	Bid Summary and Proof of Advertising	July 2008	100%	10/20/08
2.1.4	Construction Notice of Completion	December 2008		3/12/09
2.1.5	Photo Documentation (Pre, During, and Post)	throughout	100%	throughout
2.2 EXHIBIT A cont'd	Install Two Dry Weather Diversions and Storm Drain Outfalls	--	100%	3/12/09
2.2.1	Adapted Plans	Sept. 2008	100%	October 2008
2.2.2	Contract Change Order	Sept. 2008	100%	1/16/09
2.23	Construction Notice of Completion as As-Built Drawings	April 2009 Sept. 2010	100%	NOC, 4/20/09, ABD, Sept. 2010
2.24	Photo Documentation (Pre, During, and Post)	throughout	100%	throughout
3.1	Annual Progress Summary	Sept. 2007, Sept. 2008	100%	9/20/2007; 9/30/2008 revised 11/15/2008; no summary in 2009; Final Report serves as 2010 summary
3.2	Progress Reports	Quarterly	100%	07/20/07, 9/26/2007, 1/15/2008, 4/15/2008, 7/15/2008, 10/20/2008, 1/16/2009, 4/20/2009, 7/20/2009, 10/15/2009, 1/2/2020
4.1	Draft Project Report	Sept. 1, 2010	100%	Aug. 30, 2010
4.2	Final Project Report	Sept. 30, 2010	100%	Sept. 30, 2010
EXHIBIT	CEQA/NEPA Documents, Signed Cover	July 2006	100%	7/20/09,

Item	DESCRIPTION	Due Date	% Of Work Complete	Date Submitted
C	Sheets for all Permits			9/26/2009
EXHIBIT D	Adjoining Land Owner Notification	n/a	n/a	n/a

APPENDIX B
Plant Report

Wetland Plant Report, August, 2010
By George McMenamin

Purpose

The purpose of this report is to provide information, as to the survival and growth potential, for the plants placed in the Soquel Creek wastewater treatment wetland. Survival, growth and function are parameters used to assist in the decision as to the appropriate nature of these species, for this environment. As conditions in this wetland are different from those found in a natural environment, experimentation is necessary if the plants are to survive, spread and perform the require functions of the wetland design. It is likely that only healthy, mature plants planted in 2008 are potentially functioning and achieving significant nutrient (fecal matter) uptake. Although some of the remaining plants have potential, they are likely not yet mature enough to function in a significant manner.

Discussion

There are conditions that limit analysis of growth and survival for the plants placed in this wetland, particularly for plants placed onsite in 2008. First, there are questions as to the identity and numbers of the plants placed in the wetland in 2008. The plants and numbers found do not fully match with the original lists. It is suspected that the nursery supplying and person planting did not know the identity of all species. Second, the condition of the plants at the time of planting is not fully known. The root conditions were not observed and above ground size were not noted at the time of planting. Third, some of the species were grouped together under limited environmental conditions. This limits short-term analysis of these species' effectiveness under variable conditions. Fourth, previous to the April 2010 planting, the site was weeded by personnel with limited plant recognition skills. Inadvertently, some of the plantings were pulled or cut. Finally, the planting location was not initially mapped for each plant, limiting analysis of the effects of some environmental variables, at this time.

As conditions in this wetland are different from those found in a natural environment, it is expected that the data gathered in August 2010 will provide a base for analysis on the effects of some environmental variables. These variables include: solar radiation (sun or shade), salinity, nutrient levels, herbivory, root saturation, competition and effects of a reversed salt water-fresh water regime.

Note: All discussion of plants are based on the data, as of August 2010

These 3 plants are listed first due to their invasive potential

Plant List		**Date of purchase/planting**
Iris pseudacorus	**Full removal is recommended**	2008
Typha augustifolia	Regular maintenance is recommended	2008
Scirpus californicus		2008

Plant List	Date of purchase/planting
Anemopsis californica	7/2009
Carex nudata	2008
Carex tumicola	4/2010
Grindelia stricta sp.	7/2009
Juncus effuses var. brunneus	2008? (Likely listed as Juncus xiphoides)
Juncus effuses var. pacificus	2008? (Likely listed as Juncus xiphoides)
Juncus patens	7/2009, 4/2010
Juncus phaeocephalus	4/2010
Juncus xiphiodes	2008
Mimulus cardinalis	2008
Potentilla anserine ssp. Pacificus	7/2009, 4/2010
Scirpus cernuus	7/2009
Scirpus microcarpus	2008
Sisyrinchium californicum (recruit)	4/2010

Plant Discussion

Iris pseudacorus – 2008
Full careful removal and disposal of ALL plant parts is highly recommended.
This species is not a native. It is listed on CalEPPC Noxious Weed List-B. It is listed an injurious weed, in Nevada. It can be toxic to livestock. It is thriving in the wetland. Under all conditions where it is located on the site, it is growing, spreading and flowering. It reproduces from flower and vegetatively. The potential for it to spread upstream is high.
Possibly, a shade tolerant, native species of Iris, such as Iris fernaldii could be tested for viability.

Typha augustifolia – 2008
Typha has a moderate potential to spread into sunny, wet areas. The floral heads carry both male and female seed and the seed is spread by the wind. This would allow Typha to be carried far upstream and into wet, sunny areas, along Soquel Creek. Additionally, Typha augustifolia can grow in water over 2 feet deep and tolerates high levels of salinity. Finally, Typha reproduce vegetatively, from pieces of rhizome.
If this species is left on site, floral heads may be removed periodically and care should be made to avoid pieces of rhizome entering the water.

This species appears to have been cut back to the ground, in the past. Three of the plants, in full sun, have developed floral heads. This species has shown the ability to survive and do well under these wetland conditions. However, none of the plants in the shade have developed floral heads, so it should be regularly monitored for reproductive capacity.

Scirpus californicus – 2008
This Scirpus may be an invasive species in moderate to full sun, but is unlikely to develop flowers in the full shade or light sun. Some concern does exist if pieces of rhizome are broken off and fall into the water, but the threat should be considered low.

All but one of this species was planted in full shade (1) to light sun (2). None of the plants have developed flowers. Five of them were planted in full shade near the outlet pipe. Although the growth data does not show any significant pattern, field observation shows the plants in full shade have extremely weak stems and cannot maintain vertical growth. The plants in light sun appear to be stronger, and the plants in the full sun has the most rigid growth. I suspect that this Scirpus species has a level of shade intolerance. However, most of these Scirpus were cut back to the ground accidently in the spring of 2010 and they may recover during the rest of the summer. Salinity does not appear to be a factor in growth, but may be a factor in flowering and reproduction.

Plant Discussion

Anemopsis californica - 7/2009
Extirpated?

Carex nudata – 2008
Extirpated- This is a plant usually found in freshwater streambeds. It is unlikely to survive in these conditions.

Carex tumicola - 4/2010
The surviving five Carex are small, with less than 65% living tissue. Four of the five do have a few flowers. It appears that the lower light level for all plants (2) may be the key factor in the condition of these plants. Although greater sunlight may help these plants, the areas of high sunlight are limited. It is recommended that no more Carex tumicola be planted until the survivability of the present plants is established.

Grindelia stricta sp. - 7/2009
The four Grindelia left on the site are not doing well, but have survived. They are located in an area of mostly shade (2), mid way between the inlet and outlet points. It is likely that this plant would do better in the sunny section, if winter salt concentrations could be tolerated. This plant is known to tolerate moderate levels of salt, so I recommend that two of the Grindelia be transplanted into the sunny area, as a test.

Juncus effuses var. brunneus - 2008?
This Juncus is doing well on the site under all conditions, with most of the plants producing flower. The data suggests that the plants towards the inlet pipe do not grow as tall as the plants further away. This may be due to the higher winter salt concentration. This species and Juncus in general, are subject to herbivory by waterfowl.

Juncus effuses var. pacificus - 2008?
The two Juncus pacificus are healthy and flowering, but have not spread, on the site. Both are located in the sunny area near the inlet pipe. I suggest that several additional plants be placed in areas of mostly shade (2), to test for shade tolerance. This species may be subject to herbivory by waterfowl, but little was observed on these two plants.

Juncus patens - 7/2009, 4/2010

Only seven Juncus patens were observed on site. All but one of these had gone to flower. The remaining three plants may have been mistaken for Juncus effusus var. brunneus, as some the brunneus were small with no flowers. In general, the Juncus patens are smaller than the Juncus effusus, but this is likely due to their age. This Juncus has a high tolerance for shade and is likely an excellent candidate to spread in the shady portion of the site, if the winter salt concentrations can be tolerated. Because of its high shade tolerance and rapid root growth when happy, this could be a key species on this site. However, waterfowl like to eat this species. I recommend that Juncus patens is monitored, until next spring, to see how it tolerates moderate salt levels and survives herbivory.

Juncus phaeocephalus - 4/2010
This species has potential on this site. Although it has been stepped on regularly, one large patch has already formed, by the gate. However, three of the four other plants are weak and small. All plants have developed only a few flowers, at this time. I recommend that this plant be provided some protection from be stepped on, until next spring, to see if it can fulfill its potential. It fills approximately the same role as Juncus xiphoides, but the increased diversity is desirable.

Juncus xiphiodes – 2008
Juncus xiphiodes is located throughout the site and is doing well and flowering with only a few exceptions. Additionally, the underground growth of this species is likely to lend itself well, to the wetland function. However, spread is limited for individual plants, at this time. This may be related to the shade or winter salt concentration. This species is likely to be a good choice for this wetland.

Mimulus cardinalis – 2008
One Mimulus is barely surviving in the shady, outlet end of the site. As this is usually a sunny, freshwater stream species, Mimulus is unlikely to do well on this site.

Potentilla anserine ssp. Pacificus - 7/2009, 4/2010
The six, original Potentilla were accidentally weeded in early spring of 2010. Despite this, Potentilla is showing excellent early signs of growth and is flowering. Additionally, it is very attractive and has ground covering potential. It is attempting to spread by stolons. However, most of the stolons appear to die, at this time. This may be due to the cool, low light summer, the young age of the plants or herbivory. One moderate patch is forming in the sunny area near the inlet pipe. As this plant has good salt tolerance and is showing good early growth potential, Potentilla should be monitored until next spring. If it can survive the shady nature of the wetland and spread, this is one of the most desirable plants for the wetland.

Scirpus cernuus - 7/2009
Although, these plants are small, all have survived, are healthy and have produced numerous flowers. Additionally, it seems to have a good tolerance for shade. However, no plants were placed in the third of the site closest to the inlet pipe. I recommend placing several more of this Scirpus closer to the inlet pipe, to test salt tolerance.

Scirpus microcarpus – 2008

No pattern is discernible for the 10 remaining Scirpus microcarpus. Originally, 25 were listed as planted, but I suspect this species was accidently thoroughly weeded, in the spring of 2010. It looks much like a weed Cyperus when young and was likely treated as a weed. However, the 10 plants that are surviving appear to be recovering. Although only one plant has flowered this may be due to the recovery process. All of these plants were found in shade (1) to low light levels (2). I recommend this plant be monitored to see if it fully recovers and produces flowers. For the purpose of experimentation, one or two of the smaller plants could be placed in the sun area.

Sisyrinchium californicum (recruit) - 4/2010
This native plant was accidently brought in with a Juncus patens this April and has grown well, producing a number of flowers. As this would be an attractive addition to the site, I recommend we see if it reseeds, on the site.

Conclusions
Final conclusions are not possible in this report, but patterns are emerging. In general, the plants in the wetland are surviving, growing and producing flowers. Enough species are established to provide some wetland function. However, continued root development and increases in density, vegetatively or through seed, are likely required for all potential plants, but the Scirpus californicus and Typha augustifolia to achieve a potentially effective uptake of nutrients. Correlation of data related to actual nutrient uptake and salinity is needed in conjunction with continued plant growth data to draw final conclusions.

Most of the species found on site have not been in the ground long enough to allow me to draw firm conclusions. However, it is possible to do so for the species planted in 2008. Plants that appear to fulfill the requirements for this wetland include: Juncus species (xipiodes and effusus), Scirpus californicus and Typha californicus, although the Typha does have some invasive potential and may need maintenance. The Scirpus microcarpus is likely to prove appropriate, but needs to be monitored further. The Mimulus and Carex nudata have proven to be inappropriate for this location. Although the Iris is doing very well, the invasive nature of this species makes the threat to lower Soquel Creek greater then the potential reward and it should be removed.

Plants with great potential but requiring more time in the ground include: Scirpus cernuus, Juncus patens, Potentilla, and Juncus phaeocephalus. Plants that may prove worthwhile, but requiring adjustments to study include: Grindelia stricta and Carex tumicola. The Anemopsis was gone from the site and it is not known whether it died or was weeded in the spring of 2010.

If an additional goal of this wetland is to provide a small patch of habitat, success is likely. The Juncus as well as several other plant species are proven attractive food sources to waterfowl and also may provide a limited nesting location. Additionally, some of these plant species are quite attractive and could be used for educational purposes or to forward planting of appropriate native species, in gardens.

Important data and anecdotal information related to nutrient/salinity uptake and plant growth and development under unusual conditions is being created at this wetland. It is recommended that collection of data continue for at least two years.

APPENDIX C
Diagrams of Centipede and Snorkel Design

APPENDIX D
As-Built Drawings

APPENDIX E
Monitoring Report with Appendices and Data